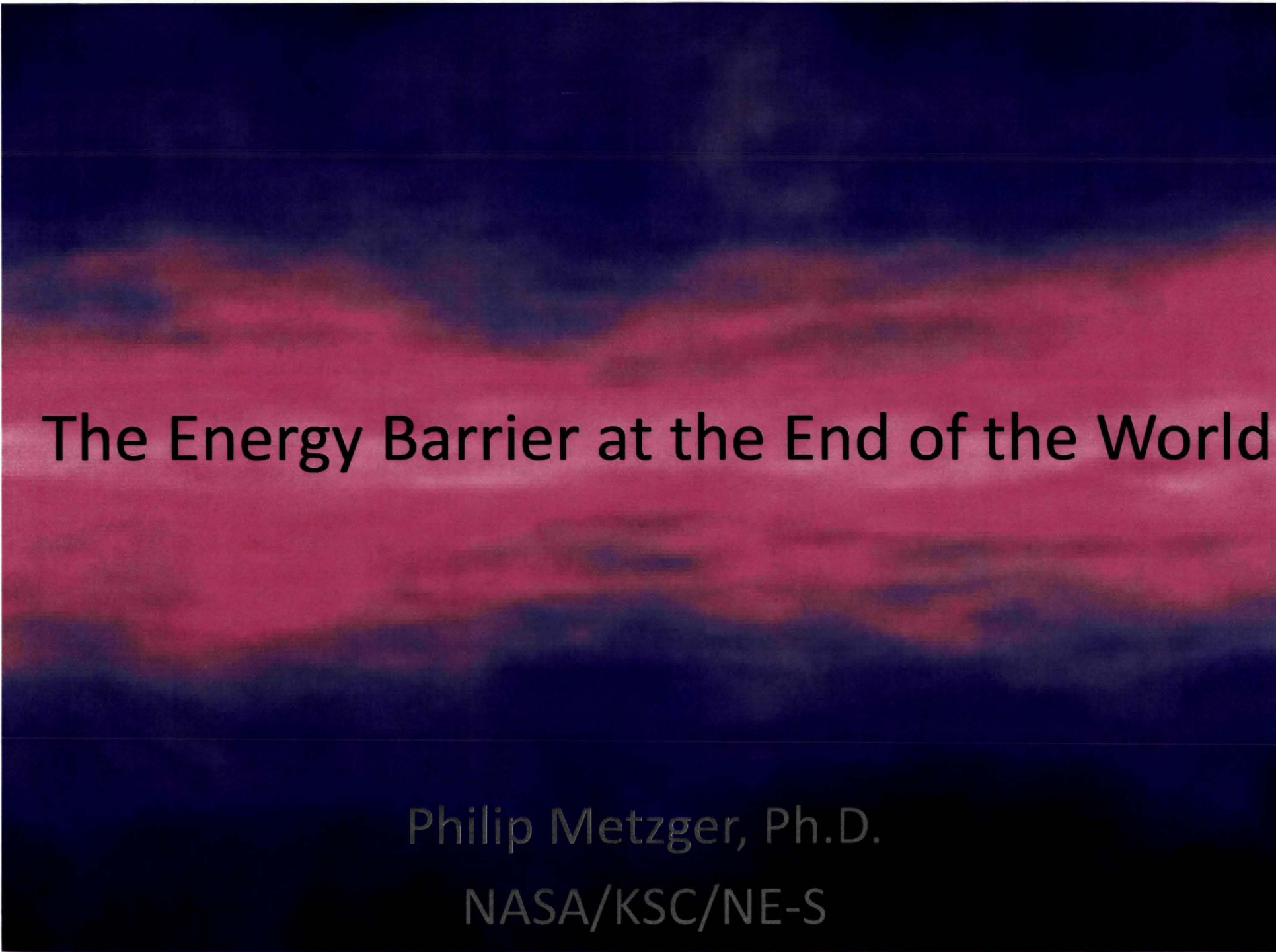




The Energy Barrier at the End of the World

Philip Metzger, Ph.D.

NASA/KSC/NE-S

The Kardashev Scale of Civilizations

Type 1

Uses the energy
of an entire planet.

Type 2

...of an entire star.

Type 3

...of an entire galaxy.



The Kardashev Scale of Civilizations



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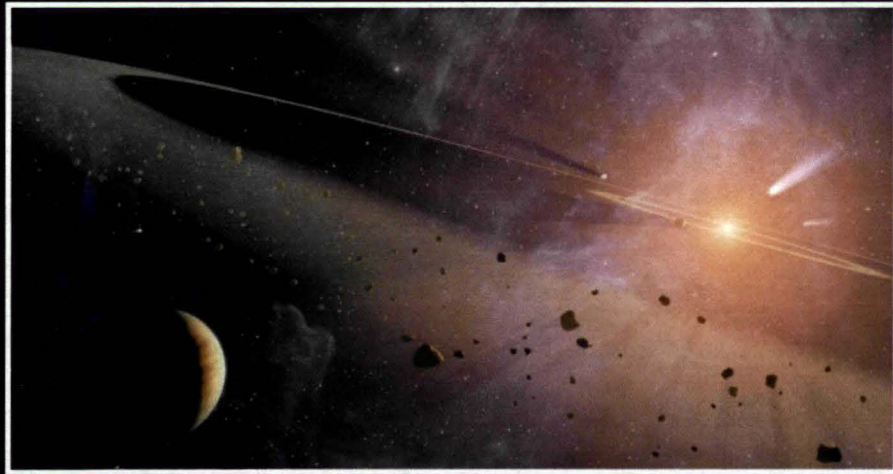
Type 3

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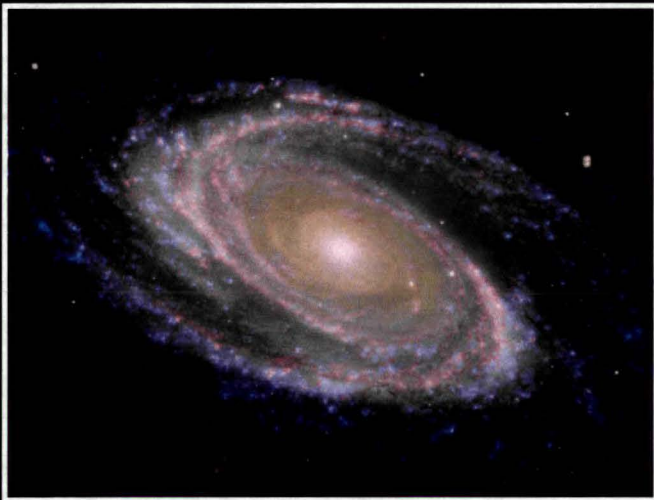
The Kardashev Scale of Civilizations

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Uses the energy
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...of an entire star.



Type 3

...of an entire galaxy.

How About some Earlier Categories?

Type 3 ...an entire galaxy

Type 2 ...an entire star

Type 1 ...an entire planet

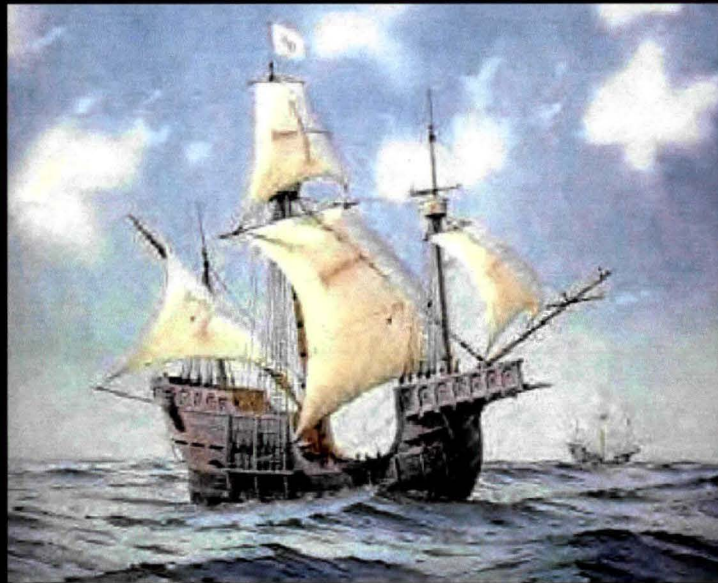
How About some Earlier Categories?

Type 3 ...an entire galaxy

Type 2 ...an entire star

Type 1 ...an entire planet

Type 0 ...an entire continent →



How About some Earlier Categories?

Type 3 ...an entire galaxy

Type 2 ...an entire star

Type 1 ...an entire planet

Type 0 ...an entire continent →

Type -1 ...an entire river valley ↘



Image credit: Eric Desrentes, Panoramio

How About some Earlier Categories?

Type 3 ...an entire galaxy

Type 2 ...an entire star

Type 1 ...an entire planet

Type 0 ...an entire continent →

Type -1 ...an entire river valley

Type -2 ...an isolated enclave ↘



Image credit: Eric Desrentes, Panoramio



Image credit: Eric Desrentes, Panoramio

Phil Metzger's Predictions

We are essentially Type I right now.

For Type II we have a choice:
achieve it in 50 - 100 years,
or possibly never at all.

If we achieve Type II, then Type III will
come easily and fast.

Running Into the Planet's Energy Barrier

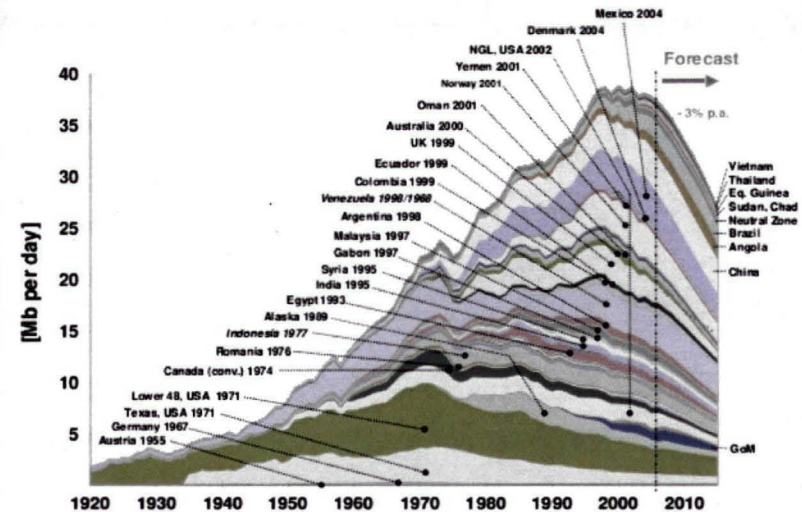


Image credit: Wikipedia



Image credit: Wikipedia

Figure 5: Oil producing countries past peak



Ludwig-Bölkow-Systemtechnik GmbH, 2007
Source: IHS 2006; PEMEX, petrobras; NPD, DTI, ENS(DK), NEB, RRC, US-EIA, January 2007
Forecast: LBST estimate, 25 January 2007

Image credit: <http://gasprices-usa.com/>



Image credit: Howard Rees

We do not have a resource problem.



What we have is an imagination
problem.

Think Globally...Act Locally.

~~Think Globally...Act Locally.~~

Thinking *Globally* is the new
way of *Thinking Too Small*.

~~Think Globally...Act Locally.~~

Thinking *Globally* is the new
way of *Thinking Too Small*.

Think outside the box.

~~Think Globally...Act Locally.~~

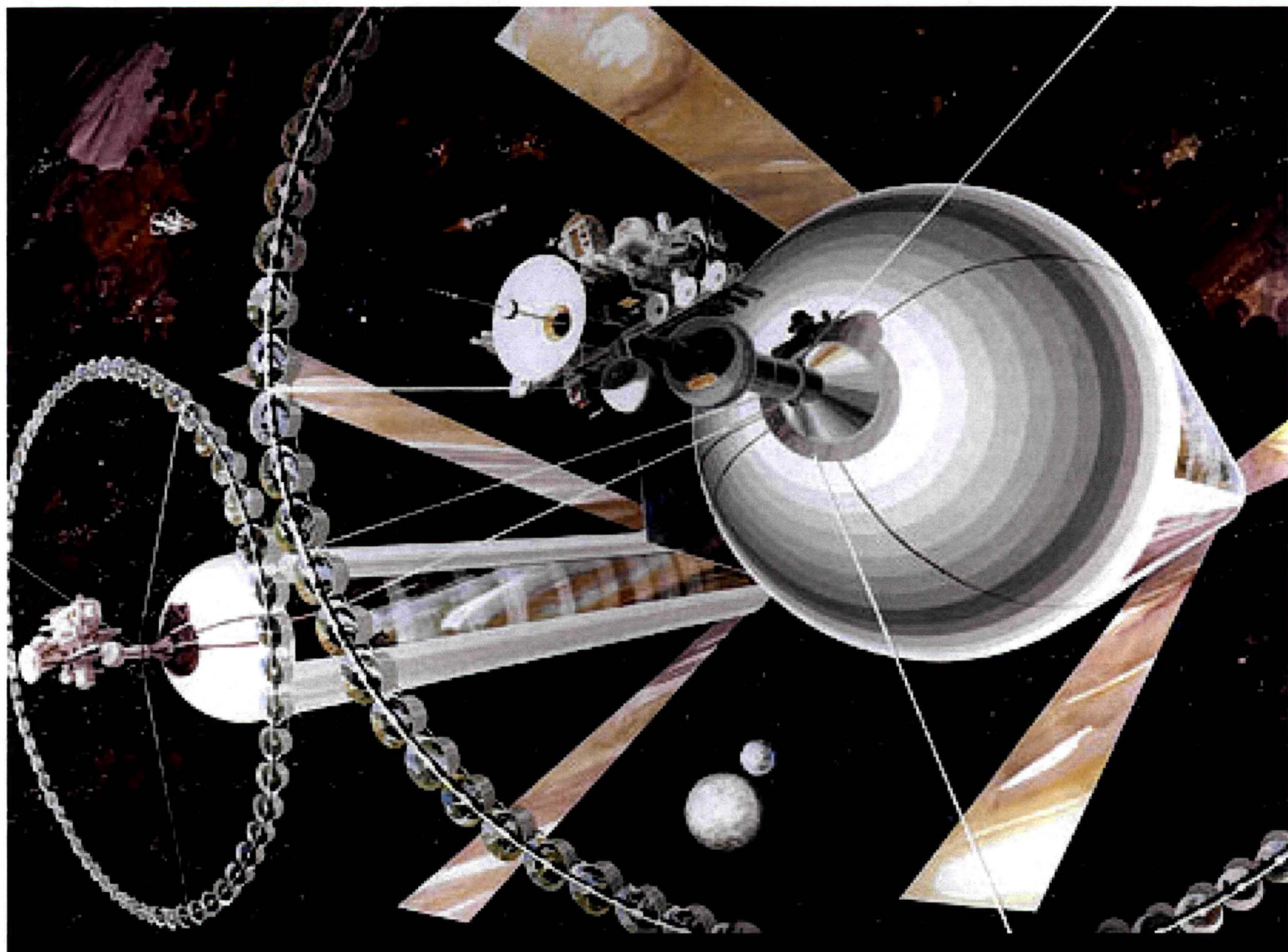
Thinking *Globally* is the new
way of *Thinking Too Small*.

~~Think outside the box.~~

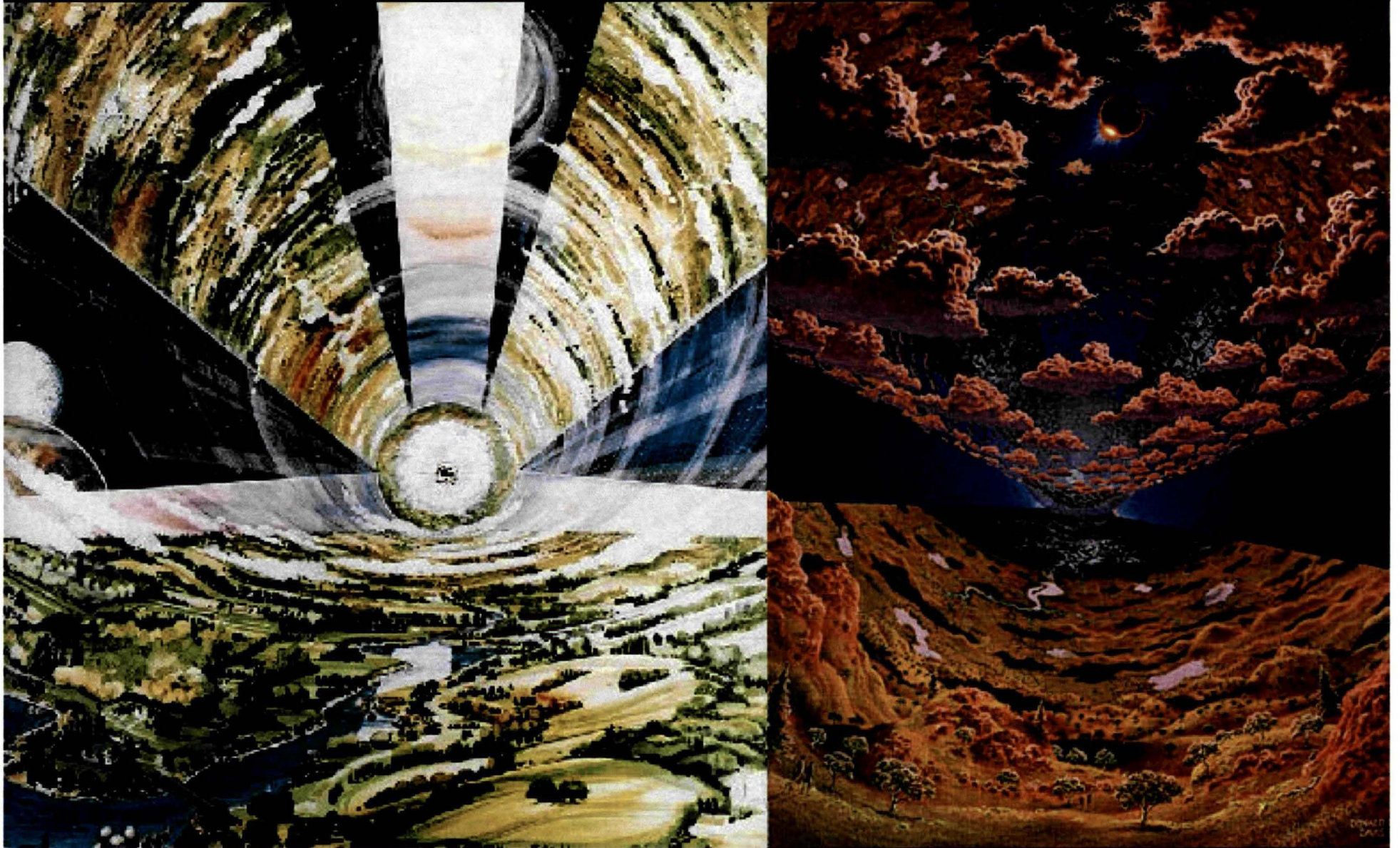
Think outside the *sphere*.

Crossing the Barriers: A New Level of Civilization

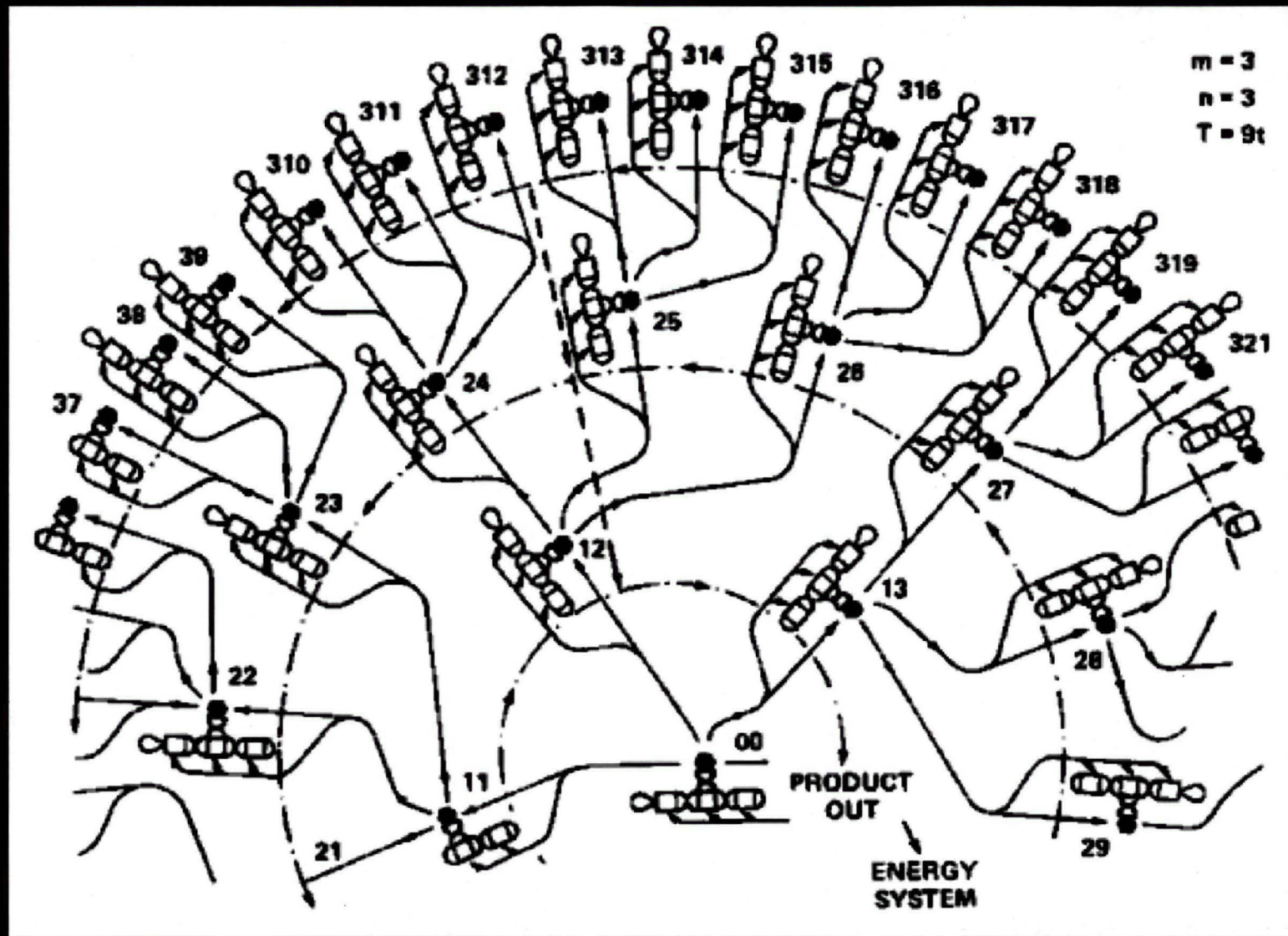




Inside an O'Neill Cylinder

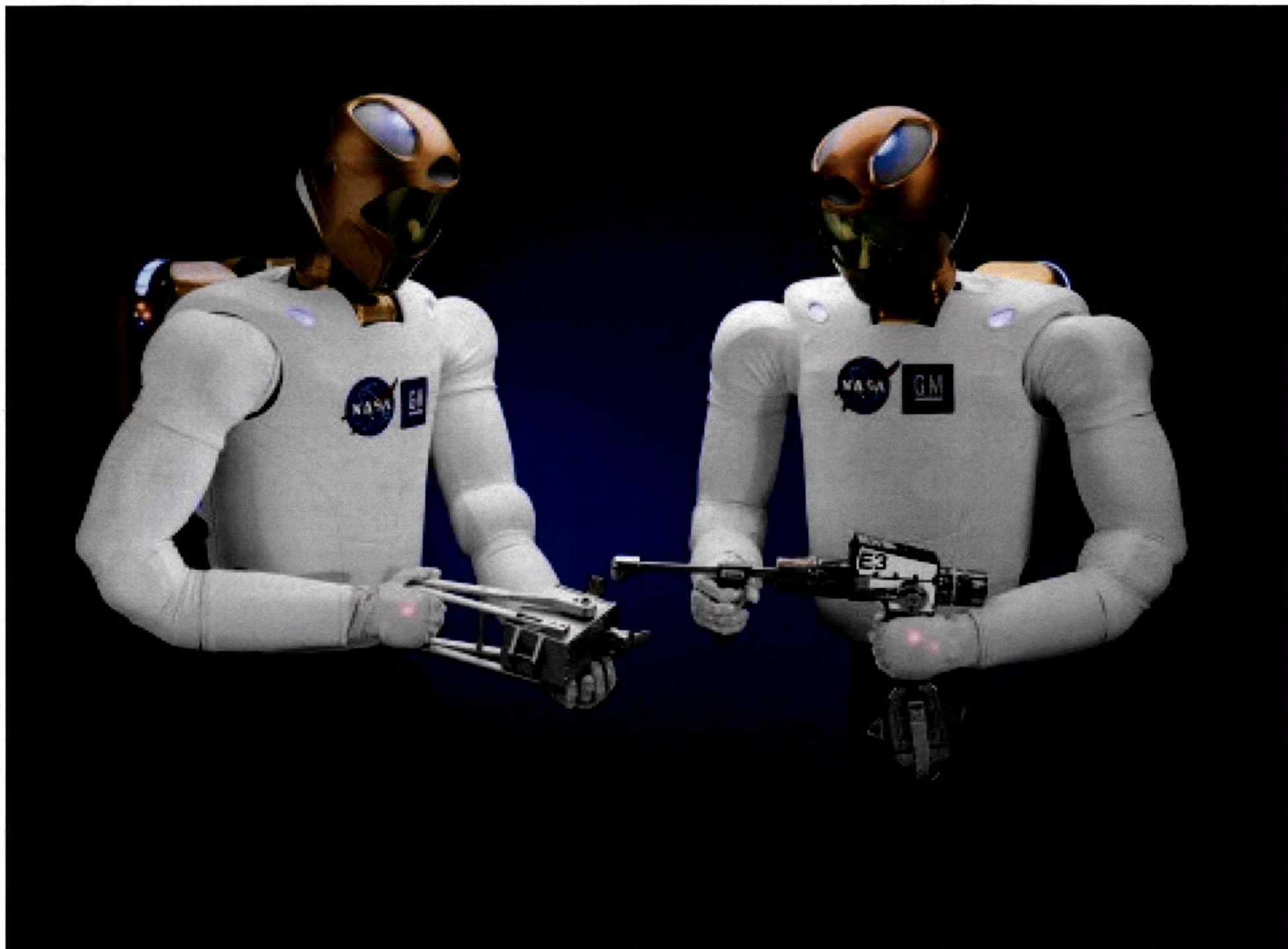


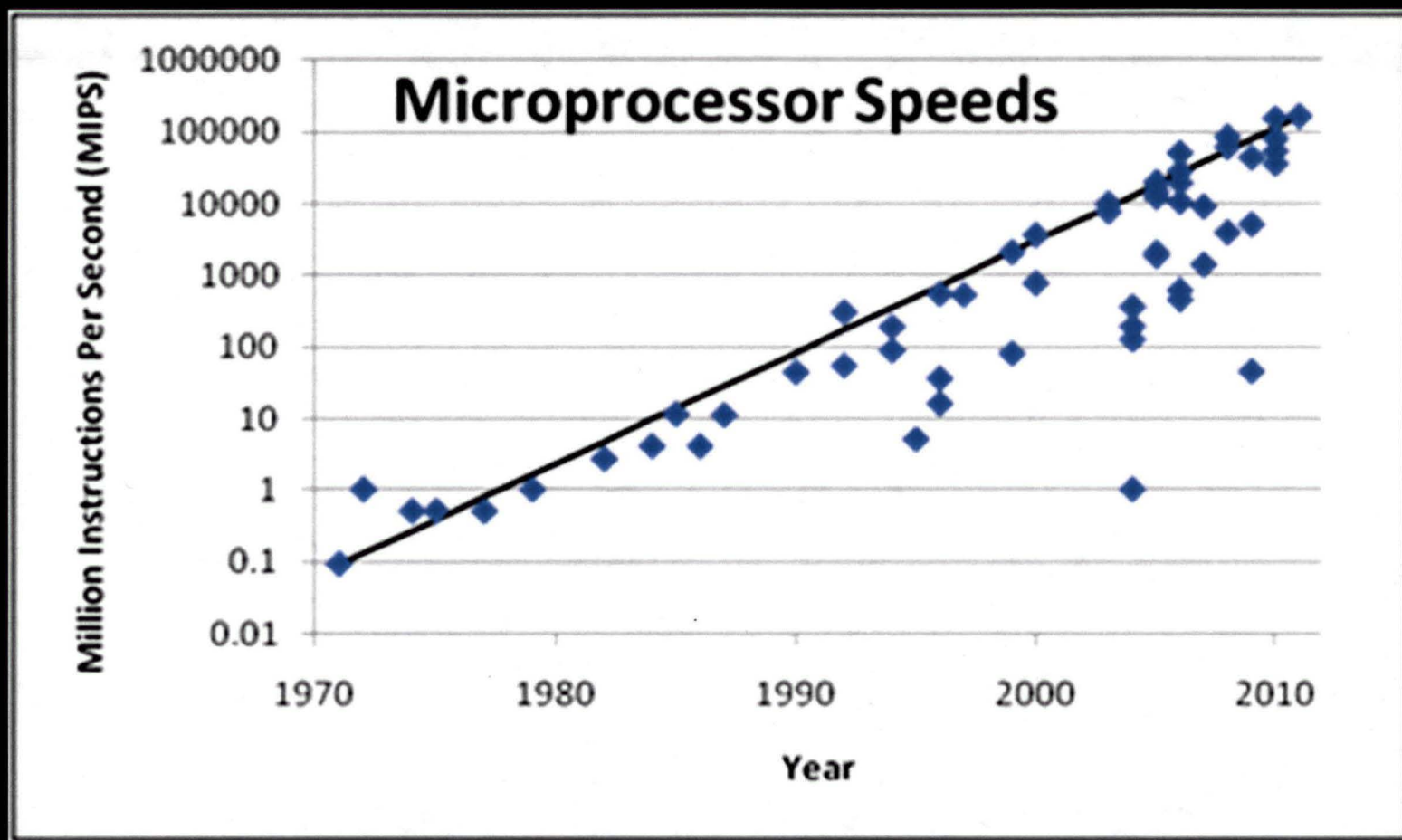
Self Replicating Lunar Factories





GAME CHANGERS



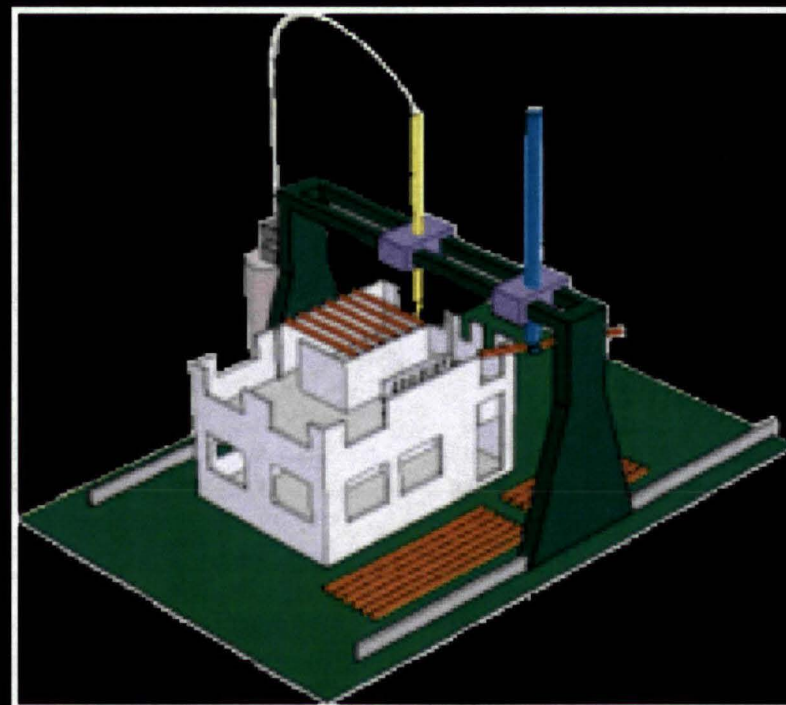


EDEN350





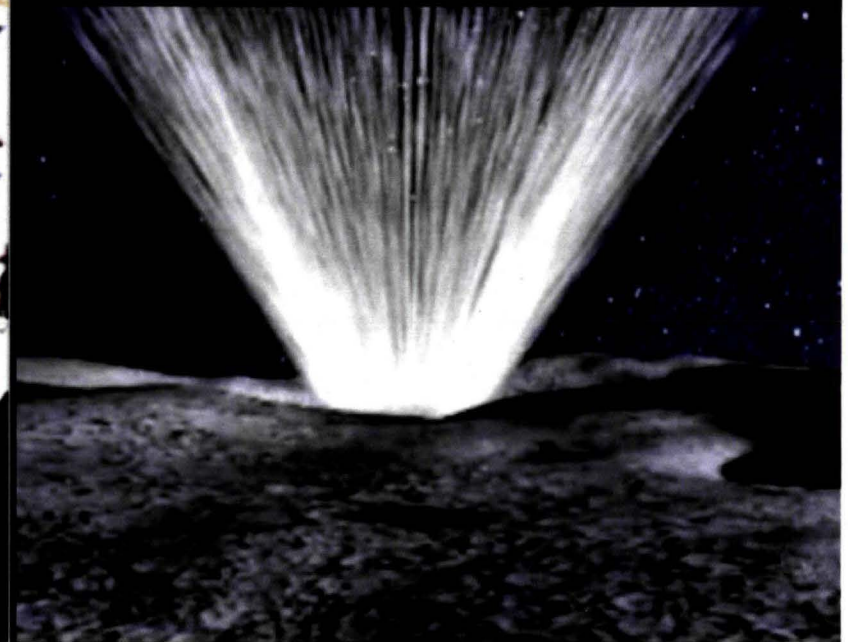
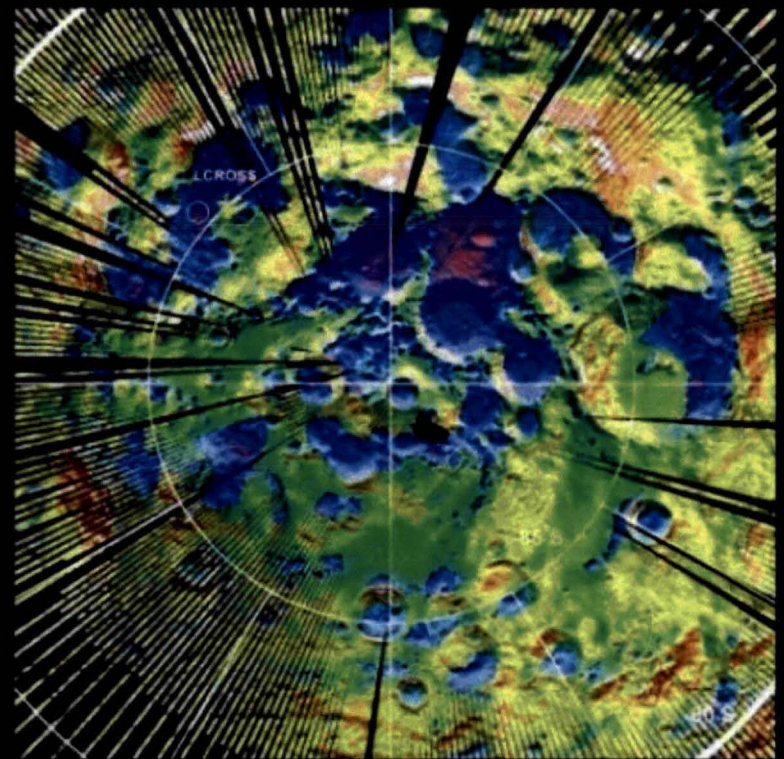
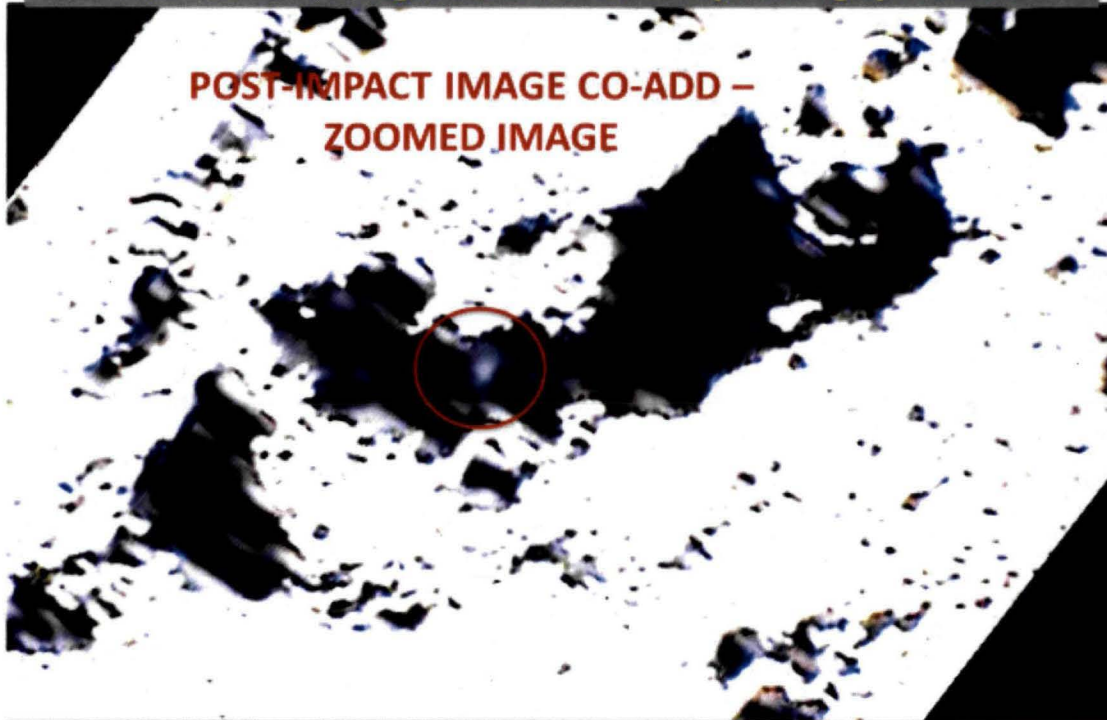
Direct Metal Laser Sintering (DMLS)

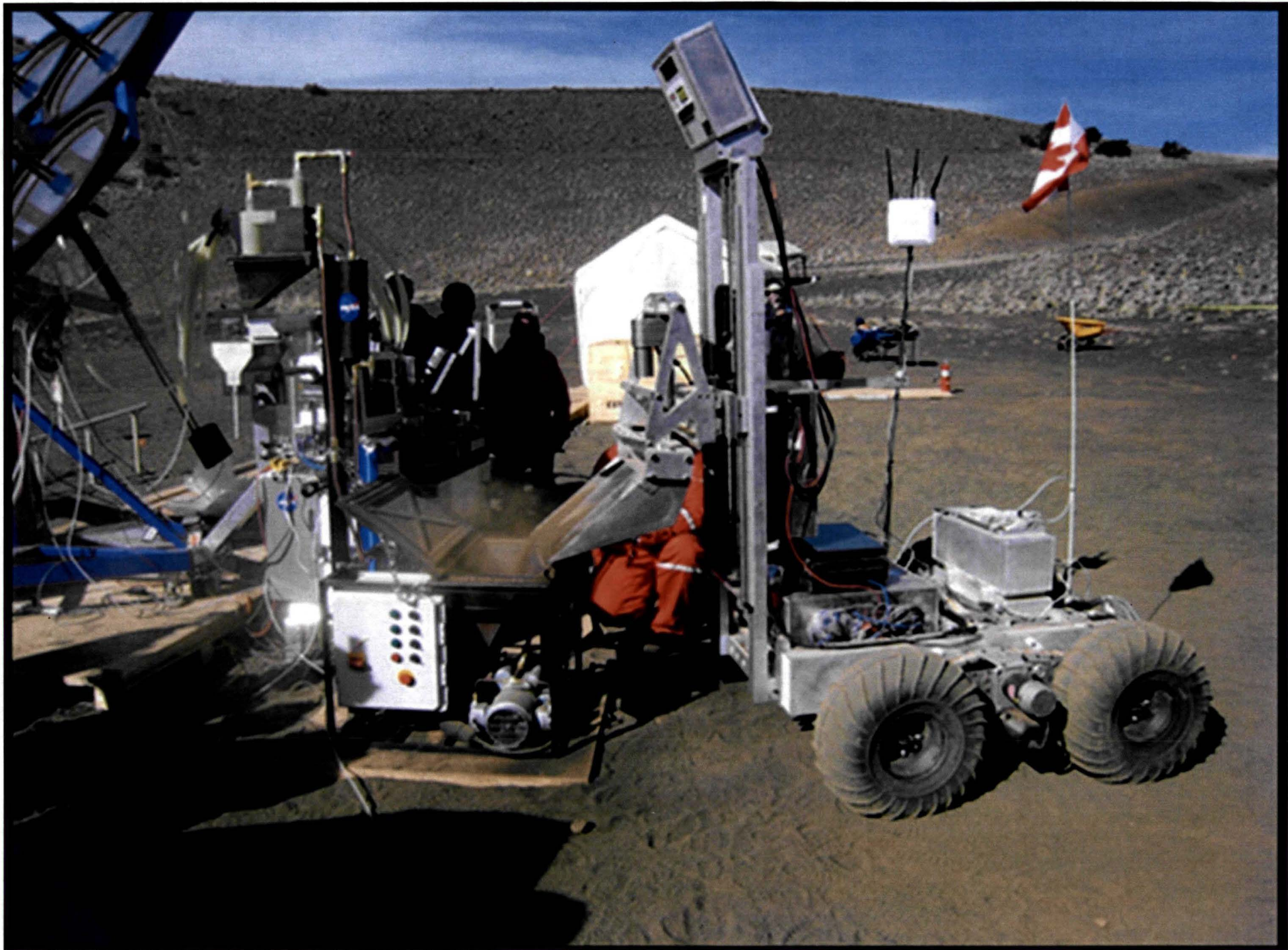


Lunar Ice

“Now there is *nothing* that
can't be made on the Moon” –
Dr. Tony Muscatello

VisibleCamera Images from LCROSS Shepherding Spacecraft







PROPOSED NEW APPROACH

Key Ideas

- Don't launch it; evolve it
 - Not a simplistic “self-replicator”
 - The biosphere and industry are not self-replicators
- Use “Appropriate Technology” at each step
 - It doesn't need to be low mass or high tech
 - It needs to be easy to make in space
- The technologies are already being developed
 - Simply “spin them in”
- The technologies are advancing exponentially

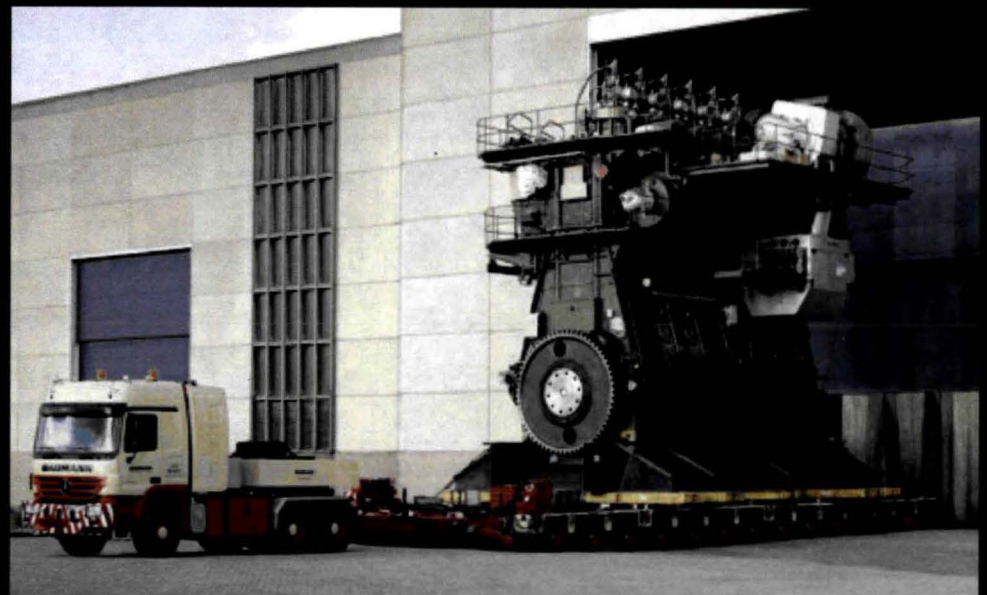


America, 1620



Europe, 1620

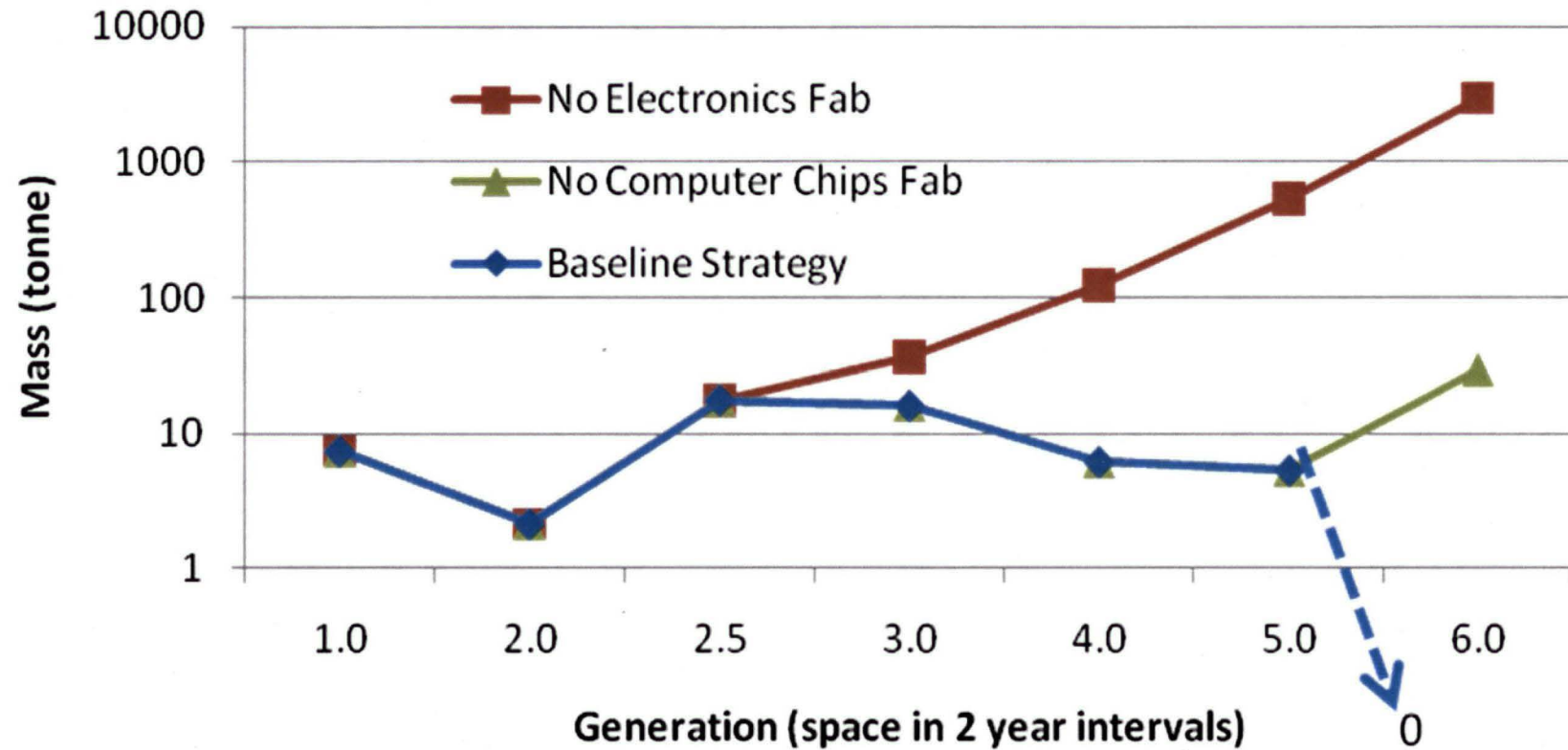
Appropriate Technology Water Pumps



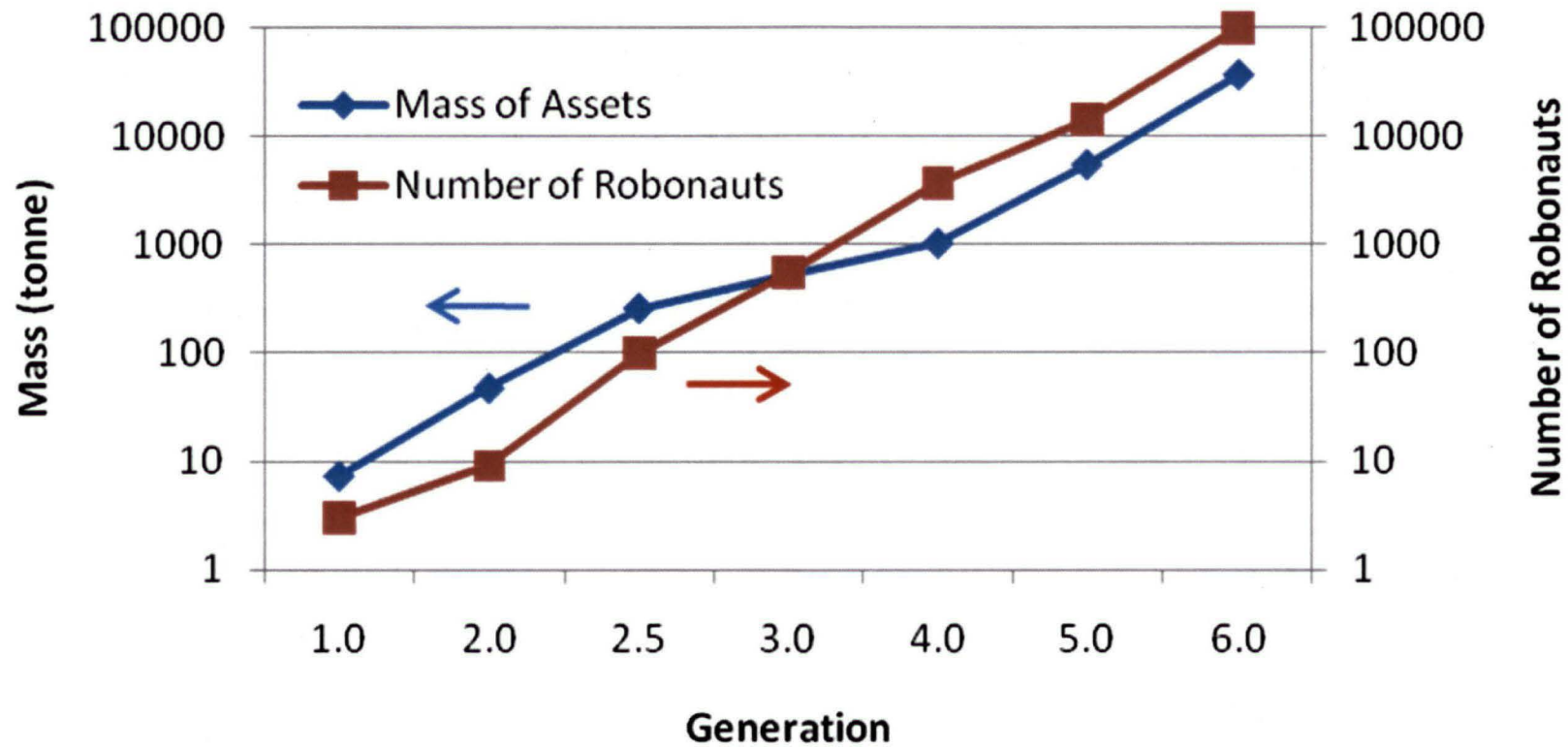
Generations of Industry (Notional)

Gen	Human/Robotic Interaction	Artificial Intelligence	Scale of Industry	Materials Manufactured	Source of Electronics
1	Teleoperated and/or locally-operated by a human outpost	Insect-like	Imported, small-scale, limited diversity	Gases, water, crude alloys, ceramics, solar cells	Import fully integrated machines
2	Teleoperated	Lizard-like	Crude fabrication, inefficient, but greater throughput than 1.0	(Same)	Import electronics boxes
2.5	Teleoperated	Lizard-like	Diversifying processes, especially volatiles and metals	Plastics, rubbers, some chemicals	Fabricate crude components plus import electronics boxes
3	Teleoperated with experiments in autonomy	Lizard-like	Larger, more complex processing plants	Diversify chemicals, Simple fabrics, eventually polymers.	Locally build PC cards, chassis and simple components, but import the chips
4	Closely supervised autonomy with some teleoperation	Mouse-like	Large plants for chemicals, fabrics, metals	Sandwiched and other advanced material processes	Building large assets such as lithography machines
5	Loosely supervised autonomy	Mouse-like	Labs and factories for electronics and robotics. Shipyards to support main belt	Large scale production	Make chips locally. Make bots in situ for export to asteroid belt
6	Nearly full autonomy	Monkey-like	Large-scale, self-supporting industry, exporting industry to asteroid main belt	Makes all necessary materials, increasing sophistication	Makes everything locally, increasing sophistication
X.0	Autonomous robotics pervasive throughout solar system enabling human presence	Human-like	Robust exports/imports through zones of solar system	Material factories specialized by zone of the solar system	Electronics factories in various locations

Mass Launched to Moon



Exponential Growth of Lunar Industry



Scenarios

- Global Relief Effort
- The Great Migration
- The Foundation
- The Space Endowment
- Anti Virus
- National Defense

We are near the limits of a Type 1 world

There is a barrier at the end of the world

The barrier is starting to hurt

We need *YOU* to leap that barrier